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Short Communication

Rediscovery of a thought to be extinct beauty: a second chance for conservation

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Abstract

Some rivulids are specialized to live in temporary or ephemeral water bodies, and for this reason they are known as annual or seasonal fishes. The fact that these seasonal species inhabit small temporary wetlands, which are easily modified and destroyed, represents a major challenge to their conservation and often puts them at risk of extinction. In Bolivia, one of the countries with the highest recent loss of primary tropical forests, of 32 recorded species, more than half (19) are endemic, and nearly one-third (9) are known only from their type localities. Of the 20 species assessed by the IUCN that occur in the country, eight have been classified in some threat category, and one of them, *Moema claudiae* (Costa, 2003), is listed as Critically Endangered and possibly extinct. The species had not been recorded in the wild for more than 20 years, and its only known locality—as well as much of its potential distribution area—have been severely degraded and are now occupied by extensive agroindustrial crops. In this work, we report the finding of a population of *Moema claudiae* recently discovered in a temporary pond within a small forest remnant surrounded by crops. This discovery allows us to provide the first live photographs of the species, along with previously unknown aspects of its biology and ecology. Furthermore, it offers an exceptional opportunity of a second chance to conserve a species that was already believed to be extinct and lost forever.

Key words: Aquatic ecosystems, Bolivia, deforestation, killifish, syntopic rivulids, wetlands

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Introduction

Rivulids (Cyprinodontiformes, Rivulidae), like other aplocheiloid fishes, are interesting objects of research due, among other traits, to their high degree of endemism important to historical biogeographic studies, their elaborated behavior, and their adaptations for complex life cycles. Members of some lineages are specialized to inhabit temporal wetlands, as their eggs can withstand long periods of drought in a state of metabolic and developmental arrest (diapause) while buried in the substrate, and for this reason they are known as annual or seasonal fishes (Myers 1952; Parenti 1981; Costa 1990, 1998a; Berois et al. 2016). Rivulids are usually oviparous with external

fertilization, but at least two genera comprise internally inseminating species, and one genus includes some self-fertilizing hermaphroditic species (Costa 1998b, 2006; Berois et al. 2016; Costa et al. 2016; Loureiro et al. 2018; Berbel-Filho et al. 2020).

The combination of limited geographic distribution, specialized habitats, and narrow ecological niches—along with other intrinsic biological and ecological traits—makes rivulids especially vulnerable to anthropogenic actions and other conservation threats and often puts them at risk of extinction (Van Damme et al. 2011; Costa 2012; Volcan and Lanés 2018; Castro and Polaz 2020; Garcez et al. 2022; IUCN 2025). Drawert (2023) compiled the state of knowledge regarding rivulids in Bolivia and observed that several species are threatened with extinction, and one species is probably extinct. Furthermore, of the 32 species present in Bolivia, 59% (19 species) are endemic, while 28% (nine species) have a highly restricted distribution and have so far been recorded only from their type localities (Drawert 2023; Drawert and Ergueta 2024). According to the global Red List of Threatened Species of the International Union for Conservation of Nature (IUCN 2025), 20 species of rivulids found in Bolivia have been assessed: three are classified as Data Deficient (DD), nine as Least Concern (LC), and eight are listed as threatened. Among the threatened species, seven are categorized as Vulnerable (VU), and one—*Moema claudiae* (Costa, 2003)—is listed as Critically Endangered (CR) under criterion B2ab (iii) and is considered possibly extinct, as the species is known only from its type locality and has not been observed again for more than 20 years (Carvajal-Vallejos et al. 2016a).

The type specimens of *M. claudiae* were collected in a temporary wetland (15°37'S, 63°35'W) at río San Pablo floodplains beside the road Santa Cruz-Trinidad, approximately 60 km north of Ascención de Guarayos, Iténez/Guaporé River basin, Bolivia (Costa 2003a; Drawert 2023). Unfortunately, the type locality has been totally destroyed, as a village was built up and the natural landscape was transformed into large agricultural fields (Carvajal-Vallejos et al. 2016a). This has resulted in habitat loss due to deforestation, modification of natural hydrological systems and pollution of the ecosystem with herbicides, insecticides and fertilizer (Carvajal-Vallejos et al. 2016a). A photograph published by Costa et al. (1997) of the type locality of *Spectrolebias filamentosus* (Costa, Barrera & Sarmiento, 1997), which is possibly also the type locality of *M. claudiae* (or at least very close to it, considering the collection data of the type material of both species), shows dense vegetation that is now no longer found for several kilometers around.

Several attempts to collect *M. claudiae* in the vicinity of the type locality have been unsuccessful so far (Carvajal-Vallejos et al. 2016a; Drawert 2023). This is partly evidenced by the number of other rivulids captured in the area that have appeared in the ornamental fish trade (*i.e. Moema beucheyi* Valdesalici, Nielsen & Pillet, 2015, *Pterolebias longipinnis* Garman, 1895, *S. filamentosus*), as well as by specimens from the same area deposited in scientific collections (Valdesalici et al. 2015; Drawert 2022, 2023). In April 2024 the two authors performed a survey with the aim to enhance the knowledge about fishes of the family Rivulidae in Bolivia. One of the goals was to rediscover *M. claudiae* in the surroundings of the type locality, or alternatively, to provide additional evidence of the possible extinction of the species.

Methods

Fish were captured using hand nets (hexagonal mesh of 6 mm, drop-shaped frame approximately 50 × 70 cm, 0.9 m handle) and were kept in 10–20 liter buckets for up to 36 hours for photographic documentation. Two groups, each of one male and three females, were kept five days in 50-liter aquaria for behavioral observation and additional photographic documentation. Live photographs were taken under artificial light (overhead LED: 50 W, 4000 lm, 6500 °K, CRI > 80; dual side LEDs: 2 × 20 W, 10000 lm, 5800 °K, CRI > 96), and no digital corrections were applied except for cropping and background color editing (saturation and homogenization). Specimens were euthanized in a 25 ml/l solution of of ethyl-alcoholic clove extract (*Syzygium aromaticum* (L) Merr. & L.M.Perry flower buds), fixed in 4% aqueous formaldehyde solution for 10 days, and then preserved in 70% ethanol; or directly preserved in 95% ethanol after euthanasia (2 specimens). The fish collection was conducted with authorization from the national competent authority in Bolivia (Authorization CAR/MMAYA/VMABCCGDF/DGBAP/MEG No. 0455/2021) and collected material is deposited in the Ichthyological Collection (MNKP) of the Museo de Historia Natural Noel Kempff Mercado (MHNNKM) in Santa Cruz de la Sierra, Bolivia. For the morphological traits (nomenclature, measurements and counts), we followed the methodology outlined in the original description of *M. claudiae* by Costa (2003a). Specimens were identified based on the original taxonomic description and diagnostic characters established for *M. claudiae* by Costa (2003a), and other congeners later described (i.e. Costa 2003a, 2004; Valdesalici 2015, 2023; Drawert 2022) belonging to the same color pattern species group defined by Drawert (2022) and the same methodology was followed for morphology (nomenclature, measurements, and counts). The nomenclature for water bodies and hydrographic basins follows SUNIT (2007) and Lehner and Grill (2013), using the Pfafstetter codes for hydrological units.

Results

We collected *M. claudiae* at a location approximately 100 km northwest of the type locality (15°04'S, 64°20'W; Fig. 1). The specimens collected match the original description of *M. claudiae* and exhibit all diagnostic characters indicated for its identification (Figs 2, 3). Males reached up to 39.1 mm in standard length (SL), and females up to 32.7 mm SL. The collected material is deposited at MNKP under catalog numbers MNKP-16794 (preserved in 95% ethanol) and MNKP-16795.

The biotope (Fig. 4) where the species was found is a seasonal blackwater pool with some suspended solids (clay) in a temporary flooded forest. It has a depth of no more than 0.4 m and a substrate composed of a layer of leaf litter over grey clay. There is no submerged or floating aquatic vegetation; the sparse emergent vegetation consists mainly of grasses established in the riparian zone. Alongside *M. claudiae*, six syntopic rivulid species were found: *M. beucheyi* (MNKP-16797), *Neofundulus* aff. *splendidus* Nielsen & Brousseau, 2013 (MNKP-16799), *Papiliolebias habluetzeli* Valdesalici, Nielsen, Brousseau & Phunkner, 2016 (MNKP-16793), *Pterolebias longipinnis* (MNKP-16788), *S. filamentosus* (MNKP-16791), and *Trigonectes rogoaguae* (Pearson & Myers, 1924) (MNKP-16789). The biotope is located in the drainage area of the Mocovi River,

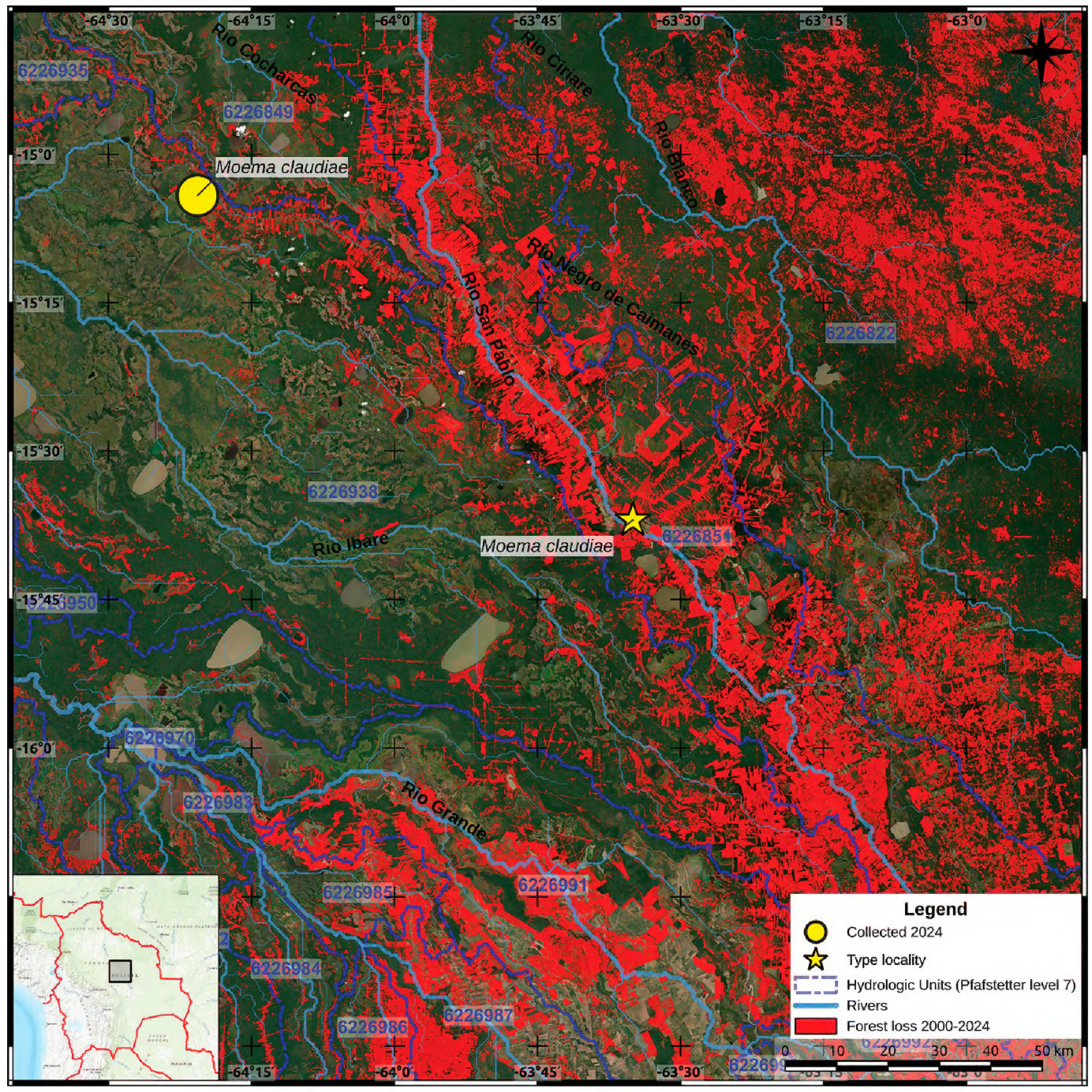

Figure 1. Occurrence localities of *Moema claudiae*. Sources: Hydrologic Units, Lehner and Grill (2013); Rivers, SUNIT (2007); Forest loss, Hansen et al. (2013, v. 1.12); Base map, ESRI World Imagery (2022).

Figure 2. *Moema claudiae* (MNKP-16795). Male (above, 38.7 mm SL) and female (below, 30.6 mm SL), one day after collection.

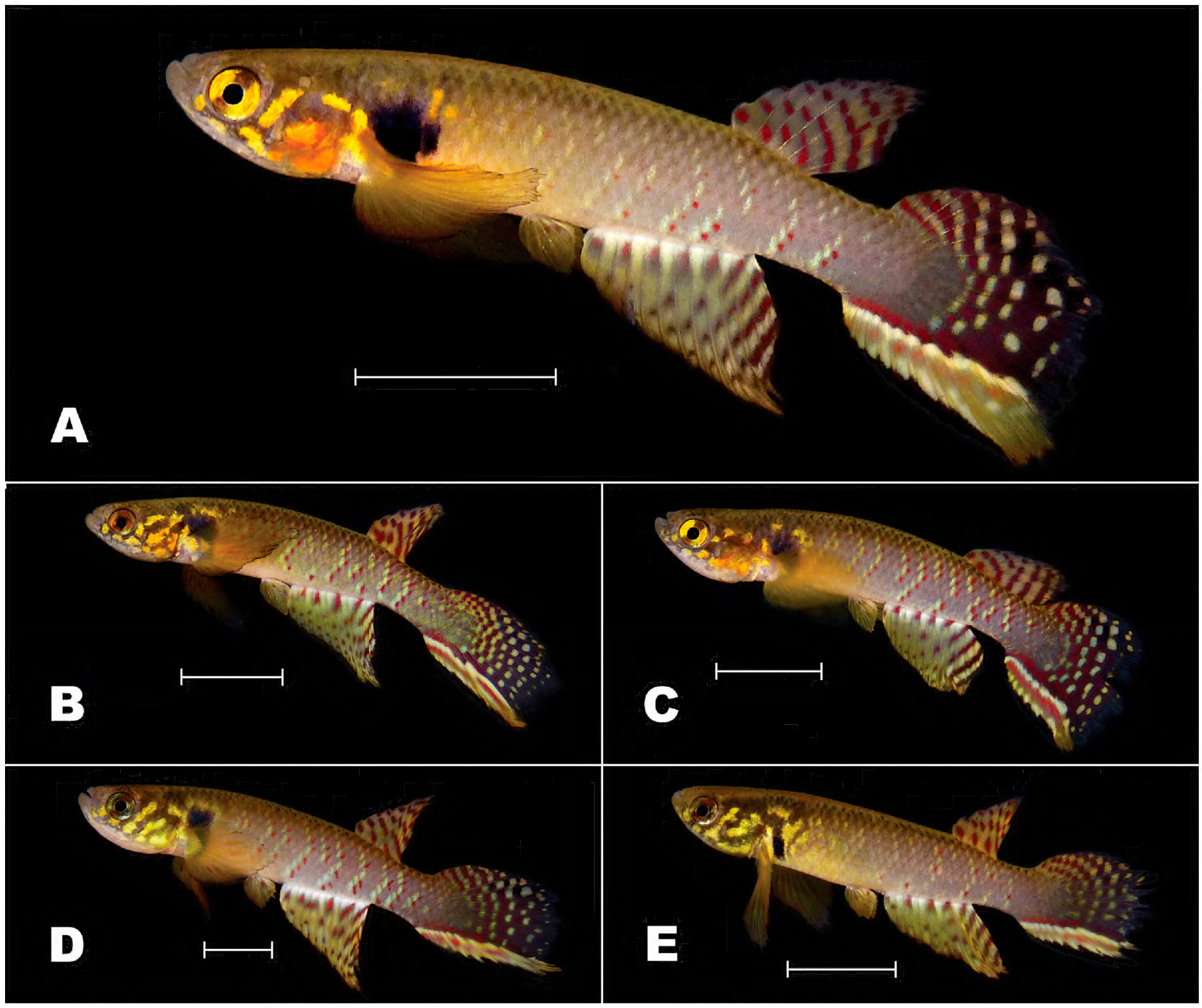

Figure 3. Color pattern variations in males of *Moema claudiae* (MNKP-16795), one day after collection. **A.** 38.7 mm SL (same male as in Fig. 2); **B.** 38.3 mm SL.; **C.** 38.6 mm SL.; **D.** 39.1 mm SL.; **E.** 35.7 mm SL. Scale bars: 10 mm (**A–E**).

Figure 4. Biotope where *Moema claudiae* was rediscovered in 2024.

part of the Ibare River basin (Hydrologic Unit 6226938), which is a sub-basin of the Mamoré River, in the Marbán province of the Beni department.

Discussion

Until now, only a greyscale drawing of *M. claudiae* had been published in the original description (Costa 2003a, fig. 2A). The live photographs presented here are the first ever published for this species. According to Costa (2003a), *Moema claudiae* differs from all congeners of its species group by the presence of a conspicuous, large, vertically elongated black humeral blotch in males, which is absent, inconspicuous or markedly smaller in other species of the group (Costa 2003a, 2004; Valdesalici 2015, 2023; Drawert 2022). This diagnostic character is clearly visible (Figs 2, 3), along with the other live coloration features described for males and females in the original species description by Costa (2003a).

The usually low syntopic diversity of seasonal killifishes suggests that within the aquatic ecosystems they inhabit, there is a precisely partitioned structure in which closely related or similar species can hardly occupy the same ecological niche, since to achieve coexistence they must differ sufficiently in their functional traits (Arim et al. 2010; Loureiro et al. 2016; Alonso et al. 2025). Until now, the highest number of species (including African Nothobranchiidae) found together was five species (Nico and Thomerson 1989; Costa 2003b; Litz et al. 2005; Loureiro et al. 2016; Reichard 2016; Alonso et al. 2018, 2025), with the possibility of reaching a maximum of six syntopic species if sympatric ones found in nearby water bodies were also considered (Alonso et al. 2018). The unusually high diversity of rivulids found at the locality (seven species) is possibly explained by the convergence of hydrographic and ecological units in the area, where the watershed of two important sub-basins (Mamoré and Iténez/Guaporé) of the upper Madeira basin meets, and where Amazonian forests collide with the savannas of the Llanos de Moxos.

According to Carvajal-Vallejos et al. (2016a), similar to other rivulids in Bolivia (Van Damme et al. 2009, 2011; Carvajal-Vallejos et al. 2016b; Sarmiento 2016a, 2016b, 2016c, 2016d; Sarmiento et al. 2016; Drawert 2022, 2023; Drawert and Ergueta 2024), the most significant threat to the conservation of *M. claudiae* is ecosystem degradation resulting in habitat loss. Between 2001 and 2024, Bolivia lost nearly 9.8 million hectares of tree cover (primary and secondary forests), with more than half of this loss occurring in primary humid forests (GFW 2025). This deforestation has been predominantly in the lowlands of northern Santa Cruz Department and more recently in the southern part of Beni Department, precisely where *M. claudiae* inhabits. Given the noticeable acceleration in deforestation in recent years, driven by policies promoting agroindustrial expansion in eastern Bolivia (Czaplicki 2023; Graham 2023; Reynolds 2023; Goldman et al. 2025), it is unlikely that this trend will slow down in the near future. In 2024 alone, over 1.8 million hectares of tree cover were lost (GFW 2025), mostly primary forests (Goldman et al. 2025), along with countless potential habitats for rivulids.

Conclusion

To our knowledge there's no other known location that possesses this seasonal killifish diversity. Therefore, we hope that this location will be protected in the near future, to preserve the only known location of living individuals of

M. claudiae, and the most diverse area that is known to date for rivulids in South America.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Use of AI

No use of AI was reported.

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Author contributions

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Data availability

All of the data that support the findings of this study are available in the main text.

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